Access in Chronic Care

Length of Stay, Conditional Length of Stay, and Prolonged Stay in Pediatric Asthma

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Objective. To understand differences in length of stay for asthma patients between New York State and Pennsylvania across children's and general hospitals in order to better guide policy.

Data Sources/Study Setting. All pediatric admissions for asthma in the states of Pennsylvania and New York using claims data obtained from each state for the years 1996–1998, $n = 38{,}310$.

Study Design. A retrospective cohort design to model length of stay (LOS), the probability of prolonged stay, conditional length of stay (CLOS or the LOS after stay is prolonged), and the probability of readmission, controlling for patient factors, state, location and hospital type.

Analytic Methods. Logit models were used to estimate the probability of prolonged stay and readmission. The LOS and the CLOS were estimated with Cox regression. Model variables included comorbidities, income, race, distance from hospital, and insurance type. Prolonged stay was based on a Hollander-Proschan "New-Worse-Than-Used" test, corresponding to a three-day stay.

Principal Findings. The LOS was longer in New York than Pennsylvania, and the probabilities of prolonged stay and readmission were much higher in New York than Pennsylvania. However, once an admission was prolonged, there were no differences in CLOS between states (when readmissions were not added to the LOS calculation). In both states, children's hospitals and general hospitals had similar adjusted LOS.

Conclusions. Management of asthma appears more efficient in Pennsylvania than New York: Less severe patients are discharged faster in Pennsylvania than New York; once discharged, patients are less likely to be readmitted in Pennsylvania than New York. However, once a stay is prolonged, there is little difference between New York and Pennsylvania, suggesting medical care for severely ill patients is similar across states. Differences between children's and general hospitals were small as compared to differences between states. We conclude that policy initiatives in New York, and other states, should focus their efforts on improving the care provided to less severe patients in order to help reduce overall length of stay.

Key Words. Length of stay, conditional length of stay, prolonged stay, asthma, pediatrics, outcomes research

Asthma is the most common serious chronic disease of the pediatric population (Newacheck and Taylor 1992; Goodman, Stukel, and Chang 1998; Mannino et al. 1998). Annually, there are approximately 200,000 childhood asthmatic admissions in the United States, representing more than three billion dollars in expenditures per year (Weiss, Gergen, and Hodgson 1992).

Since asthma admissions consume such a large proportion of pediatric health care resources, differences in the style of treatment of asthmatic patients may contribute to substantial differences in health care expenditures. While much has been written concerning differences that may exist in length of stay (LOS), expenditure, and style of practice between children's and general hospitals that care for children (Meurer et al. 1998; Silber, Gleeson, and Zhao 1999a), and between states with regard to hospitalization rates (Goodman, Stukel, and Chang 1998), LOS, and resource utilization (Samuels et al. 1998), a clearer understanding concerning the differences between the treated populations and the care given across such hospital groupings is needed to better guide policy. What is apparent from the literature is that (1) New York hospitals have especially long LOS as compared to other states (Homer et al. 1996; Goodman, Stukel, and Chang 1998) or as compared to pediatric LOS guidelines (Sills et al. 2000; Harman and Kelleher 2001; Rutledge 1998; Bauchner, Vinci, and Chessare 2000); (2) children's hospitals generally have greater charges associated with asthma admissions and often longer patient stays than general hospitals (Meurer et al. 1998; Silber, Gleeson, and Zhao 1999; Samuels et al. 1998), although adjustment often makes these length-of-stay figures more similar (Meurer et al. 1998); and, (3) health maintenance organization (HMO) concentration is relatively lower in New York

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(38 percent) than in Pennsylvania (45 percent) (ISH Health Group 1996). However, it remains unclear why LOS differences exist between hospitals located in different states and between hospitals with different characteristics.

To gain a better understanding as to why differences in LOS exist between hospitals, this study examines two new measures of hospital length of stay. By studying not just the length of stay, but the odds that a stay will become prolonged, and the length of stay after a stay is prolonged (defined as the "conditional length of stay" [CLOS]) (Silber et al. 1999b), this report aims to provide insight into state, city, and hospital differences in the patterns of stay for asthma patients. Through this approach, we aim to aid policymakers to better understand some potential etiologies for these differences, so that future policy initiatives can better focus on likely avenues for successful interventions.

METHODS

Patient Population

We obtained claims data on all pediatric admissions ages 1–17 in Pennsylvania for the period 1/1/96–12/31/98 and in New York State for the period 1/1/96–9/30/98. Patients admitted to psychiatric and nonacute care hospitals were not included in this study. Data from Pennsylvania were provided through the Pennsylvania Health Care Cost Containment Council (PHC4). Data from New York were provided through the New York Department of Public Health Statewide Planning and Research Cooperative System (SPARCS) dataset. The selected working datasets included only admissions after 4/1/96 and before 6/30/98 in both states in order to be able to use prior admissions data to define the variable "previous admission rate" and to study readmissions.

Statistical Methods

Defining Outcomes

The study uses four outcomes for analysis at the patient level, all adjusted for severity of illness on admission: (1) length of hospital stay (LOS) in days; (2) prolonged stay (yes/no) modeled as the probability that a stay will exceed a specified point defining a prolonged stay; (3) conditional length of stay (CLOS), the number of days from the prolonged point to discharge; and (4) readmission (yes/no) indicating readmission within three weeks of discharge.

Each outcome describes different aspects of medical care. The overall LOS provides insight into the overall allocation of resources by the provider. The prolonged stay variable describes the ability of providers to effectively treat and discharge the less complicated patient in a rapid manner. If a patient stay is not prolonged and the patient went home rapidly, presumably there were not major complications that would have prolonged the stay. Alternatively, prolonged stay may reflect the severity of the patient, if the models lack adequate information for adjustment, since prolonged stay may be influenced by other unobserved characteristics including social factors. The CLOS describes the provider's ability to treat the difficult patient who has proven to be complicated by the fact that the stay has become prolonged (Silber et al. 1999b). Finally, readmission may either reflect inadequate treatment during the hospitalization, or alternatively, it may reflect poor outpatient and home care associated with the health care system beyond the hospital setting.

Defining a Prolonged Stay

To determine the number of hospitalization days at which a patient's stay is considered to become prolonged, we used the "New-Worse-Than-Used" (or NWTU) test of Hollander and Proschan (H-P) (Hollander and Proschan 1972; Hollander and Wolfe 1999a) as applied to hospital discharge data (Silber et al. 1999). We adapted the statistic to describe the pattern of patient discharges over time. The NWTU test determines whether the rate of discharge slows down as the patient stays longer. The H-P method determines the hospitalization day at which the hazard rate for discharge begins to decline, based on a nonparametric significance test. In previous work we had shown that prolonged stays are associated with increased complications (Silber et al. 1999). Using the same methodology, we ran the H-P test separately on New York State and Pennsylvania admissions, and found that for both states, the H-P test statistics became positive and significant at day two, hence defining day three as the prolongation point (Silber et al. 1999b). The H-P statistic Z-score approximations were 17.50 and 16.25 respectively for New York and Pennsylvania.

Outcomes Adjustment

The policy implications from differences in length of stay across groups cannot be correctly understood without adequate risk adjustment. This study uses two methods to adjust the examined outcomes: (1) LOS models and CLOS models based on Cox regression; and (2) prolonged stay models and readmission models based on logit regression.

To develop models for predicting LOS, we combined the Pennsylvania and New York datasets, and created a random split sample of the entire dataset. One half of the data was used to construct the predictive models (the development set), and the remaining half was used for validation. Datasets were combined after validation was successful, for the estimation of the final models. Model validation was accomplished using an F-test (Kleinbaum, Kupper, and Muller 1988) for an interaction model comparing the development and validation datasets. The basic LOS model was also used as the basis for the selection of independent variables for CLOS, prolonged stay, and readmission models. Although final analyses use the Cox proportional hazards model, in the variable selection process only, we fit 1/LOS using a linear regression model, rather than LOS. The outcome 1/LOS is a rate of discharge, so that a three-day stay becomes a discharge rate of one-third of a discharge per day. In terms of regression analysis, the outcome 1/LOS was utilized for three reasons. First, there are a small number of extremely long lengths of stay, and these outliers dominate least squares regression using LOS, but with 1/LOS the rate of discharge is low but not an extreme outlier. Second, a death may be coded as an infinite length of stay—never left the hospital—with a rate of discharge (1/LOS) equal to zero, so deaths are included in a sensible way in the regression. Finally, least squares regression may be used to fit many models more quickly than Cox regression for variable selection, facilitating speed of computing when testing for all interactions. We tested for all pairwise interactions, including all interactions significant at the 0.05 level using a Bonferroni correction. After variable selection, final models were constructed using Cox and logit regression.

Adjustment Covariates

Beyond standard ICD9-CM primary and secondary diagnosis codes, age, sex, race, emergency admission, and insurance type (including HMO status), we also included an estimated patient median income based on patient zip code (Goodman, Stukel, and Chang 1998), distance from the hospital as calculated from zip codes, and previous hospitalization rates, both used as proxies for complexity (Luft et al. 1990). Including these variables was aimed to account for some of the unobserved severity and missing variables that certainly exist in a study of this nature.

Counting Transfers, Deaths, and Readmissions

We started with the premise that the hospital that first admitted a patient would be held responsible for that patient's care. All LOS, whether occurring from a transfer or a readmission, was assigned back to that admitting hospital. Hence, the LOS of a specific hospitalization that began with a "transferred in" from another hospital was shifted to the initial hospital from which the patient was transferred. If this reassignment of LOS were not made, admitting hospitals would have an incentive to transfer out their difficult patients and receiving hospitals would have a disincentive to accept them. Similarly, omitting transfer patients from analysis would create an incentive to transfer difficult patients. The advantage of our approach is that problems or mistakes associated with the transfer and the initial care prior to transfer will be attributed to the first hospital. There were only 77 transfers out of 38,310 admissions (0.2 percent).

Deaths, though very rare (only seven), were treated in a number of ways. When calculating the H-P statistics or using Cox regression models, deaths were coded as the longest stay in the dataset, although the H-P statistics were unchanged if we used a very extreme number such as ten thousand days for deaths. When computing rate of discharge (or 1/LOS), we coded deaths as an infinite stay simply by coding 1/LOS equal to 0.

Finally, readmissions were defined as any readmission within three weeks from discharge of the index hospitalization. We analyzed LOS both with and without the LOS of the readmission and interval between admissions. We generally report the results of LOS patterns without using readmissions, but note that using the readmission LOS did not significantly change our results or conclusions. Furthermore, we performed a sensitivity analysis using one-week, two-week, and four-week definitions of readmission, rather than our initial three-week definition. Our results were virtually identical, and hence we report only the three-week results.

Defining Children's and General Hospitals

The label children's hospital as used in this study does not coincide with the official designation of children's hospital as defined in the membership criteria of the National Association of Children's Hospitals and Related Institutions (NACHRI website). We chose to define a children's hospital to reflect both a hospital specialization focused on children, or an emphasis on training pediatric caregivers. The definition was developed prior to data analysis. Hospitals were designated "children's hospitals" if either of the following criteria were met: (1) 90 percent or more of patients admitted to the hospital for any given year were younger than the age of 17; (2) the hospital is in the top fifth percentile in the state with respect to the volume of pediatric admissions between 1 and 17 years of age and the hospital also: (a) has a pediatric residency program or (b) has a primary affiliation with a medical school. Using this definition, we designated hospitals as either children's hospitals or general hospitals.

RESULTS

Hospital and Patient Population

Using the definition of children's and general hospitals, Table 1 displays important hospital characteristics associated with each hospital type. We have also displayed these results by state. Among the 155 hospitals in Pennsylvania who admitted children between ages 1–17, 10 were children's hospitals and 145 were general hospitals. In New York State there were 13 that were children's hospitals and 143 general hospitals. Children's hospitals tended to be larger, admitted considerably more cases of asthma per year, had higher nurse staffing ratios, and generally had greater availability of various types of high technology (results not shown) than general hospitals. Hospitals in New York State were somewhat larger than in Pennsylvania, and admitted more asthma cases on average. However, other than size, hospital characteristics in New York were similar to those in Pennsylvania.

Table 1 also presents the distribution of children's hospitals and general hospitals across Pennsylvania and New York State. As can be seen, there were 38,310 patients in the study, of whom 12,892 (33.7 percent) were treated in children's hospitals and 25,418 (66.3 percent) were treated in general hospitals. Children's hospital admissions comprised 47 percent of asthma admissions in Pennsylvania and only 18.8 percent of admissions in New York State. There were 12,760 patients admitted in Pennsylvania (33 percent) and 25,550 (67 percent) patients admitted in New York State between 4/1/96 and 6/30/98.

As presented in Table 2, those patient characteristics that were included in the regression models developed in this study show important differences both between children's and general hospitals and between New York and Pennsylvania. Patients admitted for asthma in children's hospitals had a greater prevalence of comorbidities than those admitted to general hospitals. Comorbidities showing especially large differences between children's and

Table 1: Hospital Characteristics by State and Children's Hospital Status

Total sample size: 38,310 *Sample size in PA: 12,760* *Sample size in NY: 25,550*	*PA Children's Hospital*	*PA General Hospital*	*NY Children's Hospital*	*NY General Hospital*	*P-Value**			
Number of patients	6,059	6,701	6,833	18,717				
Number of hospitals	10	145	13	143				
Registered nurse to all nurse ratio mean	0.94	0.85	0.91	0.87	+	0	0	+
Registered nurse to bed ratio mean	1.34	0.81	1.11	0.83	+	+	0	+
Total bed mean	425	235	743	387	+	+	+	+
Pediatric asthma cases/year mean	269	21	234	58	+	+	+	+
Pediatric patient/year mean	3552	315	3134	630	+	+	+	+

*Four tests are reported per line in the following order: PA Children's vs. PA General; NY Children's vs. NY General; NY vs. PA; and Children's vs. General. A test significant at $p < 0.05$ is denoted with a "+," a nonsignificant test is denoted by a "0." For instance, for the ratio of registered nurses to all nurses, there was a significant difference between children's and general hospitals in Pennsylvania (+), but not in New York (0), and so on.

general hospitals included sickle-cell anemia, congenital heart disease, and mental retardation. Asthmatic admissions in Pennsylvania displayed slightly lower rates of comorbidities than in New York.

Patient age was slightly younger in children's hospitals than general hospitals, but no difference in age was detected between states. Children's hospitals in Pennsylvania had a higher percentage of black patients among their asthmatic admissions than did the general hospitals, but the reverse was true in New York. The overall percentage of black patients was the same in both states.

Large differences were noted in insurance coverage across hospital type and between states. Patient enrollment in HMOs was much more common in Pennsylvania than in New York, and far more common in both states at children's hospitals than at general hospitals. Low-income patients, with median incomes equal to or less than $25,000, were far more frequent among children's hospital patients than among general hospital patients, and more common in New York than in Pennsylvania.

Other differences between hospital types and states included coding practices. Children's hospitals in Pennsylvania were more likely to code a diagnosis of "extrinsic" asthma than were general hospitals in Pennsylvania or any hospital type in New York. Codes describing "asthma, unspecified" were more commonly used in New York. Finally, patients in children's hospitals were much more likely to have been admitted in the past three months with a diagnosis of asthma than those patients admitted to general hospitals, and this was more likely in New York than in Pennsylvania. Of note, although we

Table 2: Comparison of Asthma Patient Characteristics between Children's Hospitals and General Hospitals between Pennsylvania and New York

	PA Children's Hospital	*PA General Hospital*	*NY Children's Hospital*	*NY General Hospital*	*P-Value**
Comorbidity Variables					
Any comorbidity (%)†	3.0	1.8	2.9	1.6	+ + + +
Demographic Variables					
Male (%)	61	62	60	60	0 0 + 0
Age in years mean	5.7	6.5	6.1	6.0	+ 0 0 +
White (%)	26	69	27	29	+ + + +
Black (%)	58	19	35	38	+ + 0 +
Unknown race (%)	7.9	7.6	2.7	8.9	0 + 0 +
Other race (%)	9.0	4.5	35	24	+ + + +
Insurance Status					
Blue Cross and commercial (%)	36	36	24	22	0 + + +
Medicaid (%)	17	28	52	54	+ + + +
of Medicaid, the % in HMO (%)	27	17	16	20	+ + 0 +
Non-Medicaid HMO (%)	30	26	16	12	+ + + +
Uninsured (%)	2.2	2.8	6.3	12	+ + + +
Estimated Income					
Median income $\leq$ 25,000 (%)	35	7.3	36	24	+ + + +
Median income $>$25,000 & $<$50,000 (%)	55	69	46	59	+ + + +
Median income $\geqslant$ 50,000 (%)	8.0	21	17	17	+ 0 + +
Median income unknown (%)	2.2	2.4	0.7	0.7	0 0 + +
ICD9 Codes					
ICD9 493.00: EXT Asthma w/o status asthmaticus (%)	2.0	5.3	1.8	3.2	+ + + +
ICD9 493.01: EXT Asthma w/o status asthmaticus (%)	51	5.0	1.3	7.8	+ + + +
ICD9 493.90: Asthma w/o status asthmaticus (%)	4.0	40	41	35	+ + + +
ICD9 493.91: Asthma w/o status asthmaticus (%)	43	49	56	53	+ + + +
Other asthma ICD9 codes (%)	0.2	0.6	0.1	0.5	+ + 0 +
Emergency Admissions %	77	56	76	76	+ 0 + +
Distance between Patient Home and the Hospital					
Nearest hospital	14	52	35	46	+ + + +
Not nearest hospital	83	35	60	52	+ + + +
Unknown (%)	3.5	13	4.5	1.7	+ + + +
Previous Admission Rate (%)	6.0	5.2	22	18	+ + + 0

*Four tests are reported per line in the following order: PA Children's vs. PA General; NY Children's vs. NY General; NY vs. PA; and Children's vs. General. A test significant at $p < 0.05$ is denoted with a "+," a nonsignificant test is denoted by a "0."

†Comorbidities include: diabetes, sickle cell anemia, cerebral palsy, seizures, congenital heart disease, immunocompromised, AIDS, mental retardation, trisomy, spina bifida, congenital nervous system anomaly, muscle anomaly, other chromosome anomaly, and cystic fibrosis.

report subsequent analyses with models that reflected these differences in coding of asthma type, our results were unchanged when we deleted asthma type from these models. Hence, the results to follow were not dependent on the specific coding of asthma type described above. We also found that patients were more commonly admitted from the emergency department in New York than in Pennsylvania. Therefore we did account for these differences in the models that follow.

Unadjusted Patient Differences

Table 3 displays the unadjusted data concerning LOS, prolongation rate, CLOS, and readmission rates between children's and general hospitals in New York and Pennsylvania. We report the 0.5 percent trimmed mean, trimming the top and bottom half percent to display more stable estimates that would be less sensitive to the manner in which deaths were coded (Andrews et al. 1972). However, all observations were used in the Wilcoxon Rank Sum Test (Hollander and Wolfe 1999b), in which deaths were assigned the largest ranks. We also provided estimates for LOS and CLOS with and without adding the LOS derived from readmitted patients (within three weeks of discharge) to the index hospitalization. Admissions of asthmatic patients to children's hospitals in Pennsylvania appear to have a longer unadjusted LOS, CLOS, and a longer stay once prolonged than admissions to Pennsylvania general hospitals. A different pattern was observed in New York State, where children's hospitals had fewer prolonged stays, but longer stays once prolonged, than their general hospital counterparts. Furthermore, as can be seen in Table 3, New York was associated with longer unadjusted LOS, CLOS (with readmission), and a

Table 3: Unadjusted Results: Comparison across State and Hospital Type

	PA Children's Hospital	*PA General Hospital*	*NY Children's Hospital*	*NY General Hospital*	*P-Value**			
LOS mean with readmission	2.4	2.3	3.2	3.1	+	+	+	+
CLOS mean with readmission	2.2	2.0	3.8	3.0	+	+	+	+
Prolonged (%) with readmission	23	21	30	32	+	+	+	+
LOS mean no readmission	2.3	2.2	2.6	2.6	+	0	+	0
CLOS mean no readmission	1.6	1.3	1.6	1.3	+	+	0	+
Prolonged (%) no readmission	22	20	27	29	+	+	+	+
Readmission (%)	1.3	1.3	4.5	4.0	0	+	+	0

*Four tests are reported per line in the following order: PA Children's vs. PA General; NY Children's vs. NY General; NY vs. PA; and Children's vs. General. A test significant at $p < 0.05$ is denoted with a "+," a nonsignificant test is denoted by a "0."

greater probability of prolonged stay and readmission than Pennsylvania. As noted previously, patients at children's hospitals had more comorbidities; in consequence, the situation is different after adjustment for patient characteristics in the full models.

Adjusted Results

In this analysis we explored two main sets of comparisons. The first set compared patterns of care in Pennsylvania and New York. The second set compared patterns of care at children's hospitals and general hospitals. Each main set of comparisons was adjusted for multiple patient characteristics and for hospital location ("big city" versus "outside the big city"). Each comparison was based on four outcomes of interest: The discharge rate based on LOS; the discharge rate based on CLOS; the probability of being prolonged; and the probability of being readmitted. We report models that calculated LOS without including the readmission LOS as part of the index hospitalization. Our results were generally similar, and our conclusions identical, if readmission LOS was added to the index hospitalization.

If more children are discharged each day, then the typical length of stay is shorter, so higher daily discharge rates imply shorter stays (faster discharges). Discharge rates are estimated using Cox's proportional hazards model, thereby adjusting for many differences between patients. We also present estimates of the odds of being prolonged (staying beyond three days) and the odds of being readmitted (readmission within three weeks) adjusting for differences between patients using logit regression.

Comparing Pennsylvania to New York State

Discharge rates were far higher, and lengths of stay were shorter, in Pennsylvania than in New York. Discharge rates in children's hospitals in Pittsburgh/Philadelphia were 20 percent faster ($p < 0.0001$) than discharge rates in children's hospitals in New York City. Discharge rates in general hospitals in Pittsburgh/Philadelphia were 26 percent faster ($p < 0.0001$) than discharge rates in general hospitals in New York City. Furthermore, general hospitals outside Pittsburgh/Philadelphia had 14 percent faster discharges ($p < 0.0001$) than general hospitals outside New York City.

The odds of an admission being prolonged (length of stays greater than three days) were far greater in New York than Pennsylvania. The odds of being prolonged in children's hospitals in New York City were 27 percent higher ($p < 0.0001$) than in children's hospitals in Pittsburgh/Philadelphia.

The odds of being prolonged in general hospitals in New York City were 64 percent higher ($p < 0.0001$) than in general hospitals in Pittsburgh/Philadelphia. For general hospitals outside New York City, the odds of being prolonged were 20 percent higher ($p < 0.0001$) than for general hospitals outside Pittsburgh/Philadelphia.

After patients became prolonged (stayed greater than three days), we asked if the discharge rates were similar between New York and Pennsylvania, and found that they were. The discharge rate after hospital day three (the CLOS analysis) was no faster in children's hospitals in Pittsburgh/Philadelphia (only 5 percent faster, $p = 0.30$) than in children's hospitals in New York City. Similarly, rates of discharge in general hospitals in Pittsburgh/Philadelphia were nearly identical to general hospitals in New York City (0.0 percent faster, $p = 0.98$). For general hospitals outside Pittsburgh/Philadelphia, discharge rates were only 4 percent faster than in hospitals outside New York City ($p = 0.38$). Hence, there was no evidence of a difference in CLOS discharge rates between New York State and Pennsylvania.

The odds of a patient being readmitted were much greater in New York than in Pennsylvania, despite the longer stays in New York. The odds of being readmitted from children's hospitals in New York City were 3.38 times greater ($p < 0.0001$) than from children's hospitals in Pittsburgh/Philadelphia. The odds of being readmitted in general hospitals in New York City were 2.33 times as high ($p < 0.0001$) as in general hospitals in Pittsburgh/Philadelphia. For general hospitals outside New York City, the odds of being readmitted were 2.38 times higher ($p < 0.0001$) than for general hospitals outside Pittsburgh/Philadelphia.

New York hospitals caring for pediatric asthma were thus slower than Pennsylvania hospitals, had a greater chance of prolonging their patients, and were more likely to have their patients readmitted. However, once patients stayed beyond three days, there was little or no difference in the rate of discharge (CLOS) between states. These results are shown in Tables 4 and 5.

Comparing Children's Hospitals to General Hospitals

Overall, there was little difference in the rates of discharge between children's and general hospitals. Discharge rates in general hospitals in Pittsburgh/Philadelphia were only 5 percent faster than discharge rates in children's hospitals in Pittsburgh/Philadelphia, and the difference was not statistically significant ($p = 0.23$). Similarly, general hospitals in New York City were only

Table 4: Comparing Rates of Discharge by Hospital Type, Location, and State*

Items for Comparison	Discharge Rate Ratio All Stays (LOS Analysis)		Discharge Rate Ratio Only Stays > 3 days (CLOS Analysis)	
	Ratio	P-Value	Ratio	P-Value
Pennsylvania vs. New York:				
Pittsburgh/Philadelphia children's vs. NY City children's	1.20	<0.0001	1.05	0.30
Pittsburgh/Philadelphia general vs. NY City general	1.26	<0.0001	1.00	0.98
Outside Pittsburgh/Philadelphia general vs. outside NY general	1.14	<0.0001	1.04	0.38
General vs. Children's:				
NY City general vs. NY City children's	0.99	0.47	1.14	0.63
Pittsburgh/Philadelphia general vs. Pittsburgh/Philadelphia children's	1.05	0.23	1.08	0.33

*On any given day, the discharge rate ratio compares the rate at which a given child would be sent home in two groups of hospitals. For instance, the ratio of 1.20 in the first row indicates that, on any given day, a child is 20 percent more likely to be discharged from a Pittsburgh or Philadelphia children's hospital than from a New York City children's hospital, so the length of stay will be longer in the New York City children's hospital. Importantly, this large difference for overall length of stay disappears after day three, where the rate ratio of 1.05 in the first row does not differ

1 percent slower than children's hospitals in New York City, and again the difference was not statistically significant ($p = 0.47$)

The odds of an admission being prolonged (length of stays greater than three days) were 12 percent higher in children's hospitals in Pittsburgh/Philadelphia than in general hospitals in Pittsburgh/Philadelphia, but the difference was not significant ($p = 0.26$). However, the odds of an admission being prolonged were 14 percent lower in general hospitals in New York City than in children's hospitals in New York City ($p < 0.0001$).

After patients became prolonged (stayed longer than three days), we asked if the discharge rates were similar between general and children's hospitals and found that they were similar in Pennsylvania, but were somewhat different in New York. The discharge rate after hospital day three in general hospitals in Pittsburgh/Philadelphia were similar (only 8 percent faster, $p < 0.40$) than in children's hospitals in Pittsburgh/Philadelphia. However, discharge rates in general hospitals in New York City were 15 percent faster than children's hospitals in New York City ($p < 0.0001$). Hence,

Table 5: Adjusted Results from Logistic Regression Models: Comparison of the Odds of Being Prolonged or Readmitted across Hospital Type, Location, and State*

	Odds Ratio for Being Prolonged		*Odds Ratio for Being Readmitted*	
Items for Comparison	*Ratio*	*P-Value*	*Ratio*	*P-Value*
New York vs. Pennsylvania:				
NY City children's vs. Pittsburgh/Philadelphia children's	1.27	<0.0001	3.38	<0.0001
NY City general vs. Pittsburgh/Philadelphia general	1.64	<0.0001	2.33	<0.0001
Outside NY general vs. outside Pittsburgh/Philadelphia general	1.20	<0.0001	2.38	<0.0001
Children's vs. General:				
NY City children's vs. NY City general	0.86	<0.0001	1.04	0.63
Pittsburgh/Philadelphia children's vs. Pittsburgh/Philadelphia general	1.12	0.26	0.72	0.33

*The odds that a child will stay beyond three days or be readmitted after discharge are compared for several groups of hospitals. For instance, in the first row, a child in a New York City children's hospital is 3.38 times more likely to be readmitted after discharge than a similar child in a Pittsburgh or Philadelphia children's hospital. Stays beyond three days and readmissions are much more common in New York. Odds ratios are adjusted for covariates using a logit regression model.

patients admitted to children's hospitals in New York City had higher odds of being prolonged, but were discharged more rapidly if prolonged, than if admitted to a general hospital in New York City, producing similar overall LOS.

The odds of a patient being readmitted were not statistically different between general and children's hospitals. In New York City, the odds of being readmitted from general hospitals were only 4 percent higher than from children's hospitals in New York City ($p = 0.63$). In Pittsburgh/Philadelphia, the odds of being readmitted after discharge from a general hospital were 72 percent as high as from children's hospitals, but again this was not statistically significant ($p = 0.33$). Hence, general and children's hospitals had very similar patterns of care after adjusting for patient characteristics and state. These results are shown in Tables 4 and 5.

DISCUSSION

In previous work (Silber et al. 1999b), we found that over the course of a hospital stay, the rate of discharge accelerates over the first few days, then quickly decelerates, suggesting two processes are at work: the standard treatment and discharge of uncomplicated patients, and the more problematic treatment of patients who have suffered complications. This was partially confirmed by looking directly at rates of complications, which were available in that study. The skills needed to prevent prolonged stay may be different from those involved in preventing long stays once stays became prolonged: providing standard treatment to uncomplicated patients may be different from providing effective, efficient care to patients with complications. If we think of an "easy" admission, or a patient who should be discharged rapidly (within three days in our study), we may ask, what would be the determinants of the failure to discharge such a patient by that point in time? One possibility is that inpatient systems of care may have failed. It may be that caregivers are not efficient at delivering an optimal treatment regimen in a timely manner. Another possibility is that the outpatient system of care may be inadequate. If adequate outpatient systems are not in place, caregivers may perceive a high risk of readmission if patients were discharged too soon, and therefore keep the patient longer. Whatever the reason, the "easy" patient who becomes prolonged is a sign of a system failure, either inside or outside of the hospital.

A longer CLOS than expected may point to the inadequate management of more complicated patients—in our study those patients sick enough to remain more than three days. This may be due to an inability to adequately treat the sicker asthmatic, or due to gaps in the health care system such as a lack of outpatient management, for that particular patient. It was of interest that whereas New York and Pennsylvania showed very different LOS, the CLOS measures were similar across states.

In comparing New York and Pennsylvania, New York asthma patients stay longer, are substantially more likely to stay beyond three days, and are vastly more likely to be readmitted. These differences between New York and Pennsylvania far surpass any differences between children's and general hospitals. Once a patient had stayed beyond three days, rates of discharge in New York were similar to those in Pennsylvania.

What can we learn from this pattern? It would appear that after controlling for patient comorbidities, the sickest patients, those patients with prolonged stay, had similar CLOS in Pennsylvania and New York, both within and outside major cities. This would suggest similar skills in handling complicated patients in New York and Pennsylvania. This may suggest that Pennsylvania's shorter LOS may be attributed to more efficient care reflected by the prompt discharge of those patients who can potentially be discharged rapidly (the "easier" patients), and possibly due to better management of discharged patients in the outpatient setting. The existence of better outpatient management in Pennsylvania may allow clinicians to discharge patients earlier, knowing such patients will get adequate care and not require readmission. Such disease management skills may also be due to more widespread and better implementation of asthma "pathways," although this study did not have data to directly test this hypothesis.

We asked if an HMO effect could have influenced these results. Although we adjusted for both the HMO status of the patient, and the concentration of HMO patients at the hospital (the HMO variables we had available), we still saw significant state differences. Ideally, we would like to study individual HMO asthma pathways to better define the influence of HMOs on LOS. There may be heterogeneity across pathways implemented by various HMOs that may help explain why adjusting for the HMO variables in our study did not change our main results.

We also doubt that air quality or living conditions in poor urban areas had a major influence on the pattern of these results. Specifically, hospitals outside New York City had longer LOS than any group in Pennsylvania, and LOS in Pittsburgh/Philadelphia was shorter than at any group of hospitals within New York State. Furthermore, we asked whether differences in coding practices between Pennsylvania and New York State could explain those results, noting the coding differences in Table 2. We reran all models without the ICD-9 code definitions for asthma type, and found no change in our results.

We further considered whether New York State hospitals have a higher admission threshold than Pennsylvania hospitals. If this were true, and if our models did not adequately adjust for patient severity, then our findings of increased LOS and prolonged stay may simply reflect "sicker" patients in New York due to selection bias. We doubt this explanation for two reasons. First, the rate of admissions in New York State is higher than in Pennsylvania when comparing the states overall, when comparing New York City to Pittsburgh/Philadelphia, and when comparing outside New York City to outside Pittsburgh/Philadelphia. We used U.S. census figures to determine the population of children in New York State and New York City, as well as in Pennsylvania and Pittsburgh/Philadelphia. Using our claims data, we calculated the total number of asthma admissions (with repeat admissions) in both states and across the city/regions relevant for our analysis. We then calculated the ratio of admission rates for New York to Pennsylvania for each analysis. If we compare New York City (7.2 admissions/1,000 children per year) to Pittsburgh/Philadelphia (6.7 admissions/1,000 children per year), we get a ratio of 1.073 or 7.3 percent more admissions per child in New York City versus Pittsburgh/Philadelphia. When we compare areas outside New York City (1.9 admissions/1,000 children per year) to areas outside Pittsburgh/Philadelphia (1.7 admissions 1,000 children per year), we get a ratio of 1.136 or 13.6 percent more asthma admissions per patient in regions outside New York City versus those outside Pittsburgh/Philadelphia. Hence, in an unadjusted sense, New York appears to be admitting more, not less, per capita. If our results were due to unobserved severity differences between New York and Pennsylvania, it must imply that despite the higher admission rates in New York, even in regions outside New York City, patients were still sicker (in ways not accounted for in our analysis) than in Pennsylvania. Although possible, it would seem unlikely that New York State's admission rates were higher than Pennsylvania's and at the same time consisted of appreciably sicker patients. A second reason this suggestion seems unlikely is that three-week readmission rates are much higher in New York than Pennsylvania. Even the regions outside New York City had a higher readmission rate than the Pittsburgh/Philadelphia region. Hence, it seems unlikely that New York has a higher threshold for admission than Pennsylvania.

The finding that New York State CLOS was similar to Pennsylvania, yet LOS was longer and more likely prolonged in New York State as compared to Pennsylvania, is especially interesting in light of subsequent policy initiatives in New York State aimed at reducing the asthma admission rates (Flanders 2001). The findings in our study support the initiative to bring about a change in asthma admissions in New York State. First, our study has shown that once admitted, New York State admissions are more likely to be prolonged. Clearly, reducing the number of less severe admissions in New York State will reduce some unnecessarily prolonged cases that seem to be more common in New York State than in Pennsylvania. Second, readmissions, which are more likely in New York State, should also be reduced by these new initiatives aimed at reducing asthma admissions. However, it would be important for policymakers in New York State not to ignore the hospital's inefficiency when treating less severe cases that should not require prolonged admissions. Our study suggests New York State initiatives should also work to improve systematic care for the less-severe asthmatics who get admitted, and to improve outpatient care to reduce unusually high rates of readmission, and indirectly, the rate of prolonged admissions.

The similarity between children's hospitals and general hospitals within large cities was also an interesting finding. Overall, children's hospitals and general hospitals were remarkably similar, however there were certain differences that deserve discussion. Although LOS appeared similar, there were some differences in CLOS and prolonged stay within states. In New York City, patients admitted to children's hospitals were less likely to become prolonged than those in general hospitals, but once prolonged, were more likely to stay longer (i.e., had a longer CLOS). In Pennsylvania, LOS, prolonged stay, and CLOS were similar between children's and general hospitals within Pittsburgh/Philadelphia. However, these data did not suggest that children's hospitals in New York City are efficiently handling their less severe patients, since when compared to children's hospitals in Pittsburgh/Philadelphia, the New York City children's hospitals had a prolonged stay rate that was 27 percent higher. Furthermore, small numbers of pediatric admissions to general hospitals in Pittsburgh/Philadelphia may lead to some loss of significance or instability in these estimates.

Readmission rates were the most different outcome across states. New York readmission rates were far higher than those of Pennsylvania. This contributed to longer LOS in New York than Pennsylvania, but even when not counting readmission as part of LOS, New York LOS was longer than that of Pennsylvania. This possibly suggests differences in asthma management between the states, such as the substitution of outpatient care for inpatient care.

CONCLUSIONS

We are left with the conclusion that the overall management of asthma admissions appears more efficient in Pennsylvania than in New York State, primarily due to the efficient treatment of those patients who can be rapidly discharged, and a lower readmission rate after discharge. Once patients stay beyond three days and become prolonged, there appears to be little difference between New York State and Pennsylvania. Furthermore, differences between children's and general hospitals were small as compared to differences between states, although a few differences were noted. Conclusions of this sort require the decomposition of total length of stay into prolonged stays, conditional length of stay for patients with prolonged stays, and readmissions. Without this decomposition, one could only conclude that

New York is slower than Pennsylvania, without insight into when this happens and why it is so.

These results suggest that hospitals in New York State may benefit from focusing efforts on improving the efficiency of care provided to the less severe asthma patients in order to prevent their prolonged stay. Improving initial management of patients who potentially could be discharged quickly, and improving the system of care that manages the patient after discharge, may significantly reduce the disparity in LOS between New York and Pennsylvania.

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